TOPIC: CONTAMINATION OF WATER

SUB-TOPIC: PART B: NATURAL/GEOGENIC POLLUTANTS

Supporting Transcript

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This transcript accompanies associated presentation slides and video content developed for the TIDE project in 2021, with acknowledgements and disclaimer as noted in associated files.

Slide 1

Hello, my name is Sam Addison and welcome to this lesson on contamination and specifically on natural or geogenic chemical pollutants.

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In this lesson we will begin with an introduction and the objectives. This will be followed by the main part of the lesson where will we discuss naturally occurring chemicals. The end of the lesson will have a learning exercise and details on further learning and information.

Slide 3

This lesson will provide an overview of key natural/geogenic contaminants.

This lesson will build on some of the knowledge learnt in lesson “Contamination of Water - Part A: What is contamination?”.

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The objectives of this lesson are to be able to describe how contaminants can naturally contaminate drinking water, and to be able to discuss selected geogenic pollutants that can naturally occur in water supplies.

Slide 5 - Section Break

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Naturally occurring chemicals are of particular concern since the area of contamination can be quite extensive, and because contamination can go unnoticed in the absence of a testing program. The World Health Organisation has established guideline values for compounds that can occur naturally in water.

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In the guidelines for each of these naturally occurring chemicals, the World Health Organisation provides a chemical fact sheet for each chemical. The information that is provided for each chemical includes the guideline value, the basis for how the guideline value is worked out, how the chemical occurs in water and information for remediation such as treatment performance.

The following slides will highlight several of the chemicals that are prioritized by the World Health Organisation, but importantly there are many more chemicals that are monitored and assessed in water that will not be mentioned in this lesson but can be found in the World Health Organization guidelines and chemical fact sheets.

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Arsenic in drinking water is a global threat to health, considered by some researchers to have more serious health repercussions than any other environmental contaminant.

Arsenic occurs naturally in soils and rocks, with typical concentrations of about 2-10 mg/kg. Igneous rocks tend to have low arsenic content, while shales, coals and volcanic rocks have higher levels. Arsenic is often found near deposits of sulfide minerals and ore deposits of metals such as tin and gold. In natural waters arsenic concentration can reach levels up to several mg/L.

Contamination can occur in surface water but is more common in groundwater and rainwater contains negligible amounts of arsenic. Under most geochemical conditions, arsenic in aquifers remains tightly bound to sediments, and dissolved levels remain low. However, two geochemical environments have been recognized which can lead to high levels of dissolved arsenic even when concentrations in sediments are unremarkable and these two environments are reducing conditions in alluvial aquifers, and arid oxidizing conditions.

So, where we find arsenic can be very difficult to predict and is dependent on the local conditions which can often be difficult to interpret and study. Therefore, monitoring is needed to check the levels of arsenic in our drinking water to be certain, however, studies have attempted to create global prediction maps using geostatistical modelling.

The guideline value of 0.01 mg/L is provisional due to technological limitations and difficulties of removing arsenic from water. A separate mini-lecture series is focused specifically on arsenic.

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Fluoride, along with arsenic, is one of the most serious chemical contaminants that occurs naturally in drinking water.

Fluoride is a fairly common element, with an average concentration of 300 mg/kg in the earth's crust. Surface water generally contains less than 0.3 mg/L, while groundwater can contain up to 10 mg/L, with much higher levels occasionally reported.

High fluoride levels in groundwater are primarily caused by interactions with rock and sediments, and can occur in a wide range of geological environments, including the foothills of large mountains, areas of ancient marine deposits, and areas impacted by geothermal waters. Fluoride concentrations have been observed to increase along groundwater flow lengths, due to rock-water interactions.

While the most common source of fluoride in drinking water is geological, considerable amounts may also be contributed from industrial sources or impurities in phosphorus fertilizers. Also, coal burning can release large amounts of fluoride to the environment,

Unlike arsenic however, fluoride may be beneficial at low doses and is sometimes used to improve dental hygiene, but elevated concentrations lead to negative health effects.

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Barium is present as a trace element in both igneous and sedimentary rocks, and barium compounds are used in a variety of industrial applications; however, barium in water comes primarily from natural sources.

Concentrations in drinking-water generally below 100 µg/l, although concentrations above 1 mg/l have been measured in drinking-water derived from groundwater.

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Boron concentration in rocks averages 10 mg/kg, with up to 100 mg/kg in some rock types. Boron levels in natural waters range widely, and are dependent on local geology and geochemical conditions. Boron in surface water is highly variable, though concentrations above 1 mg/L are rare. Groundwater levels range more widely, from < 0.3 to over 100 mg/L.

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Manganese is one of the most abundant metals in the earth's crust. Surface water generally contains low levels of manganese (< 0.1 mg/L), groundwater can contain much higher levels (above 1 mg/L).

A key characteristic of manganese contamination of water is that it can lead to unpleasant tastes and staining which can cause people to avoid such water sources. This can be positive as people do not receive negative health effects from manganese. Whilst this is the case for manganese, contaminants such as arsenic and fluoride are tasteless, colourless and have no smell and so people are unaware of their presence.

Slide 13

Selenium is a trace element in rocks, with an average concentration of less than 1 mg/kg. Sedimentary rocks may contain up to 100 mg/kg, while levels up to several thousand mg/kg have been reported in some coal deposits. Natural levels of selenium in drinking water are generally below 0.01 mg/L.

Slide 14

Uranium occurs naturally in rocks and sediments, with average concentration in soils and rocks of 3 mg/kg. Although the decay of uranium isotopes produces radioactivity, the main public health threat of uranium arises from its chemical toxicity as a heavy metal. The guideline for uranium is also provisional, of 0.015 mg/L based on its chemical toxicity, however, if the guideline was based on its radiologic toxicity the guideline would be approximately ten times higher, at 0.14 mg/L.

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Natural pathways such as hydrogeological flow paths for groundwaters as well as surface flowpaths (e.g. river flowpaths) and groundwater-surface water interaction can lead to the transport of contaminants in the environment

Human activity such as groundwater pumping can also impact the transport of contaminants in the environment.

Slide 16 – Section Break

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In summary there are three key points to this lesson. Firstly, there are a wide range of chemicals that contaminate water resources. The chemicals can significantly vary in toxicity and concentration in water. Arsenic and fluoride are generally regarded as the most serious and widespread natural chemical contaminants especially in groundwater.

Slide 18 – Section Break

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As discussed, a trait of some natural contaminants is that they spread over large areas, so contaminant mapping is a useful tool to predict where contamination may be. Studies and organisations have attempted to predict where contamination may be and investigate how different characteristics of local geology and geography can effect contamination levels. The learning exercise is to look into these, firstly with an interactive website and for further reading, you can read into these studies as well.

Slide 20 – Section Break

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Here is a list of references that were used in this lesson and can be used for further reading.

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For further resources the main resource is Chapter 12 of the world health organisation guidelines for drinking water quality. Chapter 12 is focused on chemical fact sheets for chemicals found in water and looks further into more of the contaminants.

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Thank you for watching this lesson and I hope you enjoyed learning about natural and geogenic contamination of water.